QUANSER
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USER MANUAL

QNET VTOL Trainer for NI ELVIS

Set Up and Configuration

QNET Trainers for NI ELVIS are powered by:

LabVIEW

CAPTIVATE. MOTIVATE. GRADUATE.

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1 INTRODUCTION

The Vertical Take-off and Landing Trainer (VTOL) is designed to teach and demonstrate the fundamentals of vertical take-off and landing flight control. The system can be configured to utalize a veriety of control methods to control the flight of the trainer. In particular, the system can be used to teach current control, and PID control fundamentals. This is done using a PC with real-time control capabilities and the NI ELVIS II. The hardware of the VTOL is described in Section 2. A schematic of the hardware components is included in Section 3, and the specifications are listed in Section 4 and Section 5. Assembly instructions are provided in Section 6. Some helpful LabVIEW hints when using the QNET VIs are given in Section 8 along with a troubleshooting guide in Section 9.

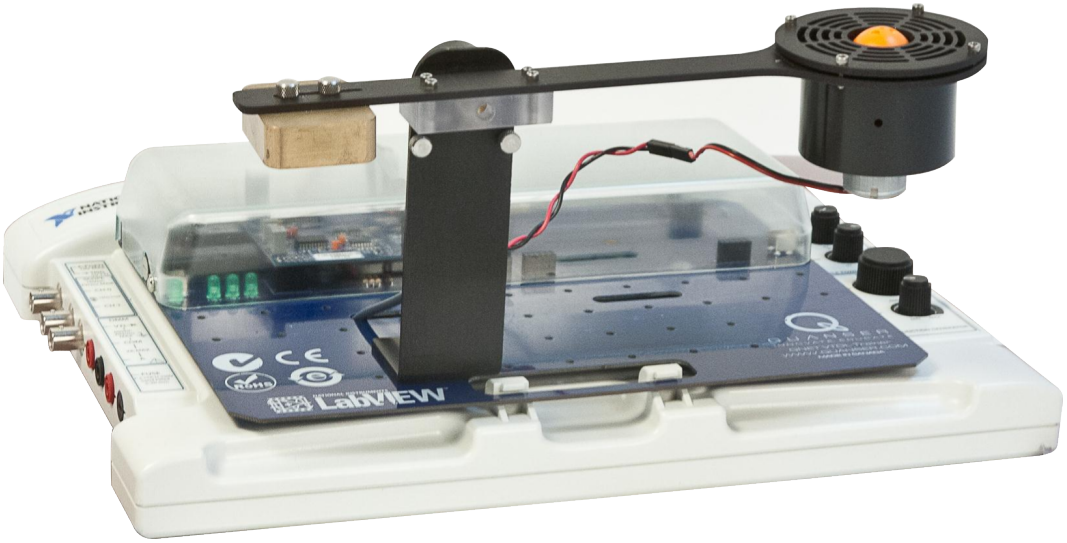


Figure 1.1: QNET Vertical Take-off and Landing (VTOL)

2 SYSTEM DESCRIPTION

2.1 VTOL COMPONENTS

The components comprising the Vertical Take-off and Landing Trainer are labeled in Figure 2.2, and Figure 2.3. and are described in Table 1.

■ **Caution:** Ensure the trainer is setup as dictated in the *QNET Setup Guide*. The trainer is susceptible to protection impairment if not used as specified.

ID#	Description	ID#	Description
1	DC motor	9	Encoder
2	Motor leads (amp to motor)	10	Counterweight
3	Propeller holder	11	Counterweight thumbscrews
4	Propeller shield	12	PCI connector to NI ELVIS: for interfacing QNET module with DAC
5	VTOL body	13	24V QNET PWM/Encoder board
6	Pivot / encoder shaft	14	24V QNET power jack
7	Support arm	15	Fuse
8	Support thumbscrews	16	+B, +15V, -15V, +5V LEDs

Table 1: VTOL component nomenclature

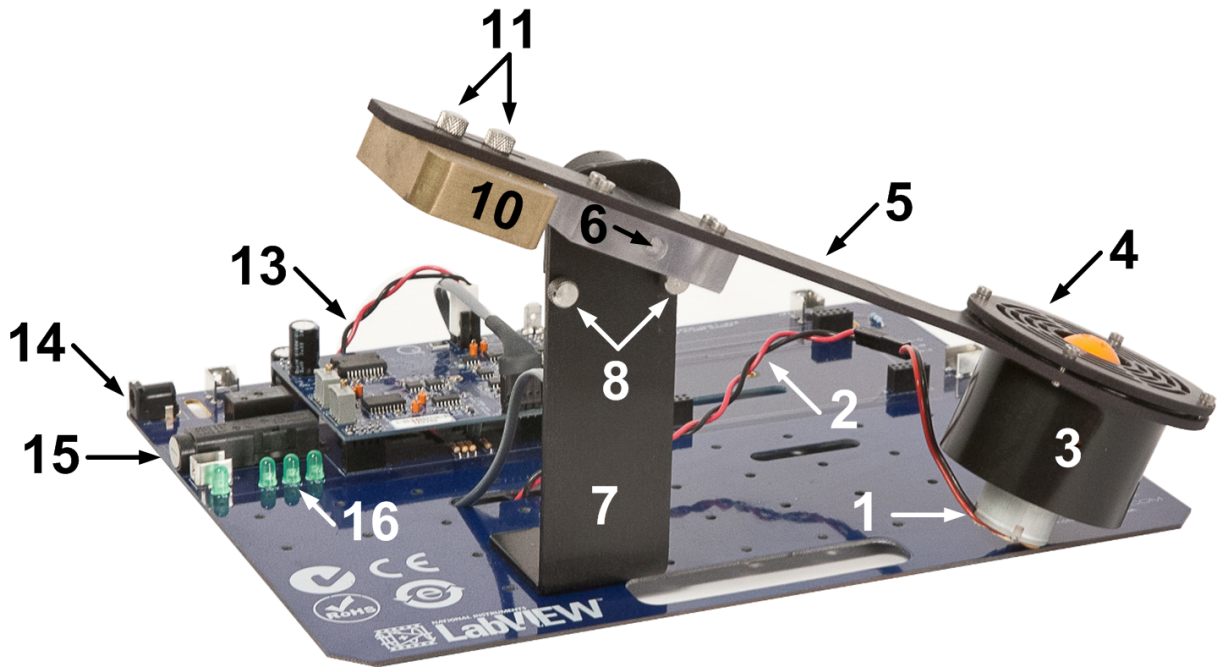


Figure 2.2: Front view of VTOL layout

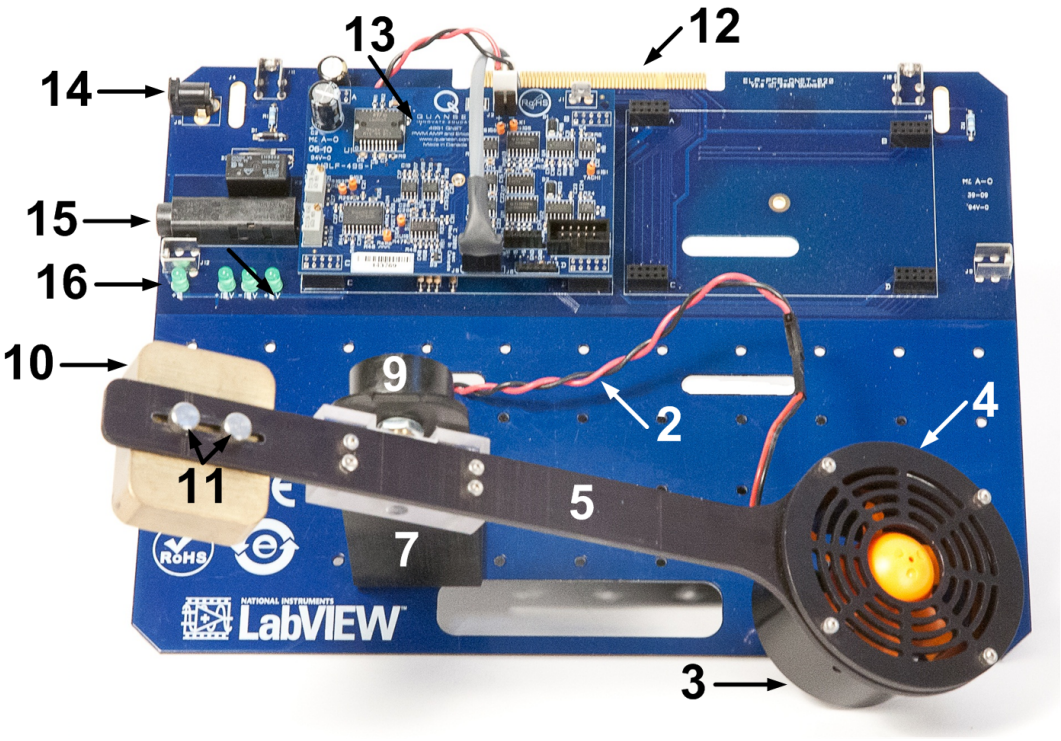


Figure 2.3: Top view of VTOL layout

2.1.1 Rotor Actuator

The EM150 DC motor and the EP2245X6 rotor have the specifications given in Table 2.

Volts (V)	Amps (A)	Thrust (g)	Thrust (oz)	Power (W)	Efficiency (g/W)	Efficiency (oz/kW)
3.6	1.5	32	1.13	5.4	5.93	209
4.8	2.2	50	1.76	10.56	4.73	167
6	3	77	2.72	18	4.28	151
7.2	3.8	95	3.35	27.36	3.47	122
8.4	4.8	119	4.2	40.32	2.95	104
9.6	5.9	141	4.97	56.64	2.49	88
10.8	6.6	152	5.36	71.28	2.13	75

Table 2: VTOL rotor specifications

2.1.2 Pulse-Width Modulated Power Amplifier

A PWM power amplifier is used to drive the VTOL DC motor. The input to the amplifier is the output of the Digital-to-Analog converter (i.e. D/A) of channel #0 on the DAQ. The maximum output voltage of the amplifier is 24 V. Its maximum peak current is 5 A and the maximum continuous current is 4 A. The amplifier gain is 2.3 V/V.

2.1.3 Analog Current Measurement: Current Sense Resistor

A series load resistor of 0.1 Ohms is connected to the output of the PWM amplifier. The signal is amplified internally to result in a sensitivity of 1.0 V/A. The obtained current measurement signal is available at the Analog-to-Digital (i.e. A/D) of channel #0. The current measurement can be used to monitor the current running in the motor.

2.1.4 Analog Voltage Measurement: Voltage Sense

The analog signal proportional to the voltage output of the PWM amplifier is available at the Analog-to-Digital (i.e. A/D) channel #4 of the DAQ. The voltage sensor sensitivity is 3.33 V/V.

2.1.5 Digital Position Measurement: Optical Encoder

Digital position measurement is obtained by using a high-resolution quadrature optical encoder. This optical encoder is mounted near the top of the VTOL support arm. The encoder shaft is used as the pivot of the VTOL body. The encoder count measurement is available at Digital Input (i.e. DI) channel #0 of the DAQ.

2.1.6 Fuse

The QNET power amplifier has a 250 V, 3 A fuse.

2.1.7 QNET Power Supply

The DCMCT module has a 24-Volt DC power jack to power the on-board PWM amplifier. It is called the QNET power supply. The +B LED on the QNET board turns bright green when the amplifier is powered.

■ **Caution:** Please make sure you use the correct type of wall transformer or you will damage the system. It should supply 24 VDC and be rated at 3.0 A.

3 SYSTEM SCHEMATIC

A schematic of the VTOL system interfaced with a DAQ device is provided in Figure 3.4.

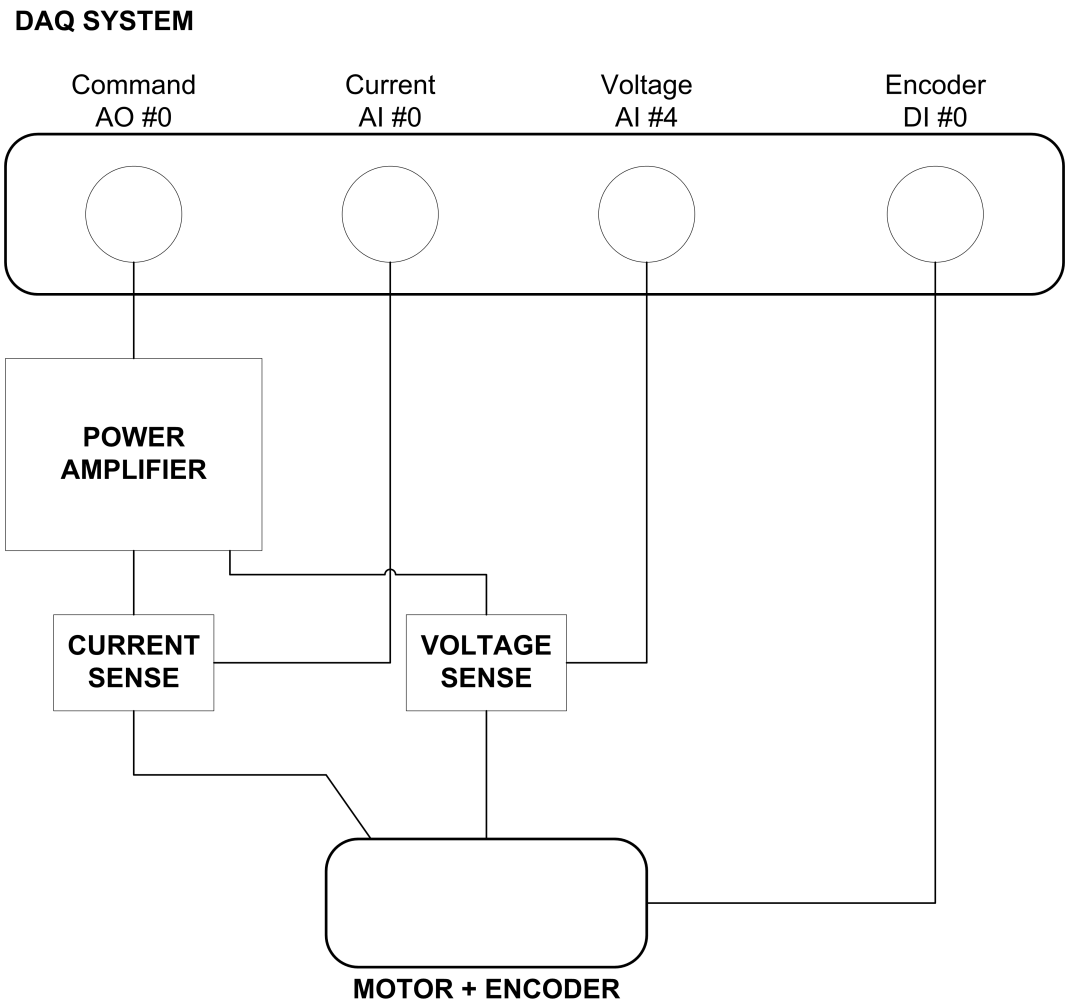


Figure 3.4: Schematic of QNET-VTOL system

4 SPECIFICATIONS

The VTOL specifications listed in Table 3 include the various masses and lengths of the system as well as the viscous damping. **Note that the viscous damping is estimated and will vary between different VTOL units.**

Symbol	Description	Value	Unit
m_1	Propeller mass	0.068	kg
m_2	Counter-weight mass	0.27	kg
m_h	VTOL body mass	0.048	kg
l_1	Length from pivot to propeller center	15.6	cm
l_2	Length from pivot to center of counter-weight	5.6	cm
L_h	Total length of helicopter body	28.4	cm
B	Estimated viscous damping of VTOL	0.002	N·m/(rad/s)

Table 3: VTOL specifications

The specifications on the VTOL system sensors are given in Table 4.

Description	Value	Unit
Current Sense:		
Current Calibration	1.0	A/V
Current sense resistor	0.1	Ω
Voltage Sense:		
Voltage Calibration	3.33	V/V
Arm Encoder:		
Encoder line count	1024	lines/rev
Encoder resolution (in quadrature mode)	0.0879	deg/count
Encoder type	TTL	
Encoder signals	A,B	

Table 4: VTOL sensor parameter specifications

5 ENVIRONMENTAL

The Vertical Take-off and Landing Trainer environmental operating conditions are given in Table 5.

Description	Value	Unit
Operating temperature	15 to 35	°C
Humidity	20 to 90	%

Table 5: VTOL environmental operating conditions

■ **Caution:** Ensure the unit is operated under the temperature and humidity conditions given in Table 5. Otherwise, there may be some issues with the heating and cooling results.

6 ASSEMBLY

This section describes how to assemble the QNET Vertical Take-Off and Landing trainer. When fully assembled, it should appear as pictured Figure 1.1.

1. Remove one of the thumbscrews located on the support arm, as depicted in Figure 6.5

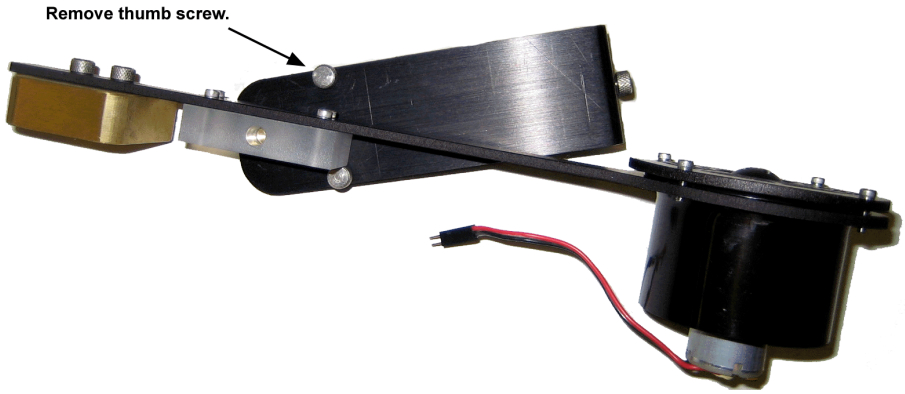


Figure 6.5: Remove thumbscrew on support arm

2. As shown in Figure 6.6, rotate the VTOL body so both thumbscrews on the support arm are located underneath and re-tighten the thumbscrew that was removed in the previous step.

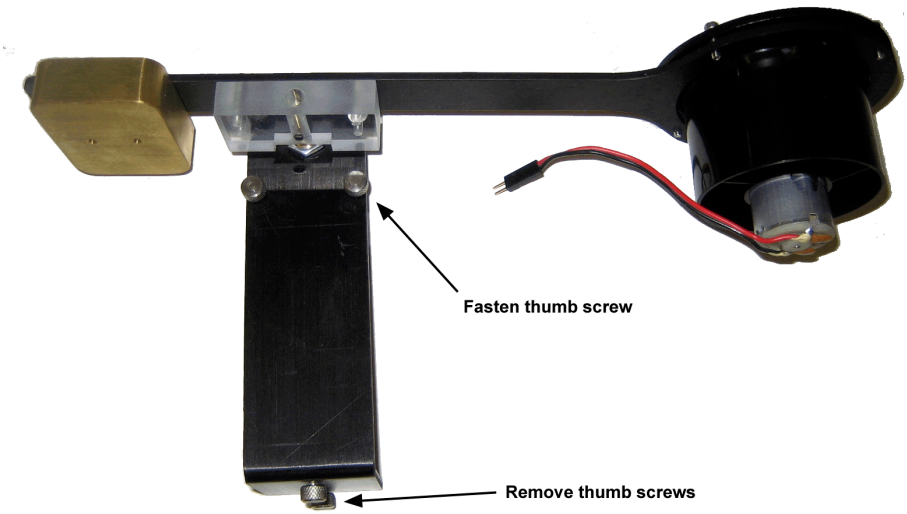


Figure 6.6: Re-tighten thumbscrew on support arm and remove the two bottom thumbscrews

3. Remove the two thumbscrews located underneath the support. The bottom screws to be removed are shown above in Figure 6.6.
4. Bring the support arm in the upright position and place the support arm onto the velcro pads on the surface of the QNET board. Align the two screw holes located on the base with two holes on the QNET module board. This is illustrated in Figure 6.7. Tighten the two supplied thumbscrews from the bottom of the module board to fasten the board onto the VTOL body base, as shown in Figure 6.8.

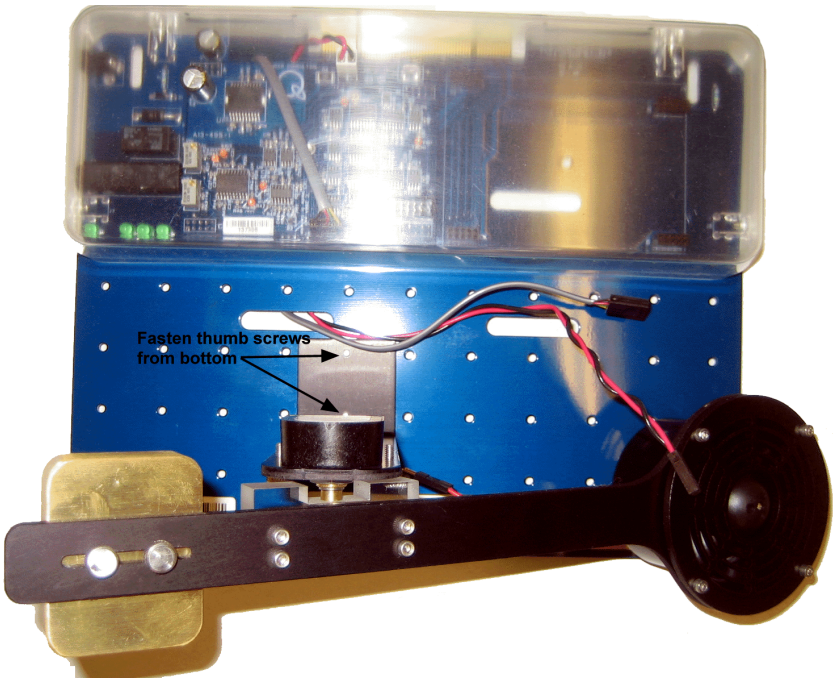


Figure 6.7: Align the two screw holes located on the base with two holes on the QNET module board

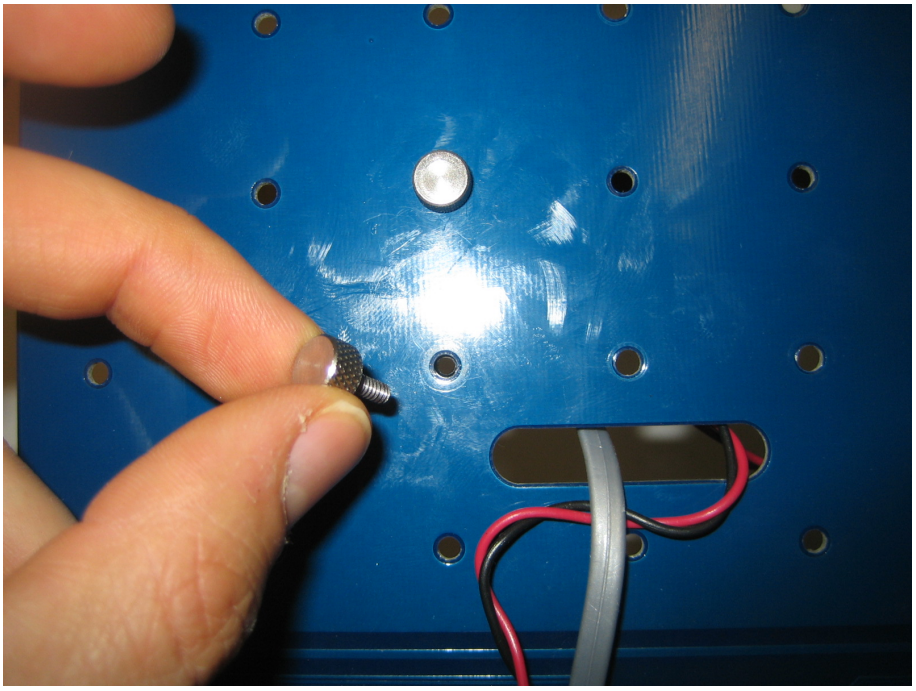


Figure 6.8: Tighten two thumbscrews

5. As demonstrated in Figure 6.9, connect the motor cable from the VTOL actuator to the wires from the QNET PWM/Encoder board. Make sure the red and black cables match.

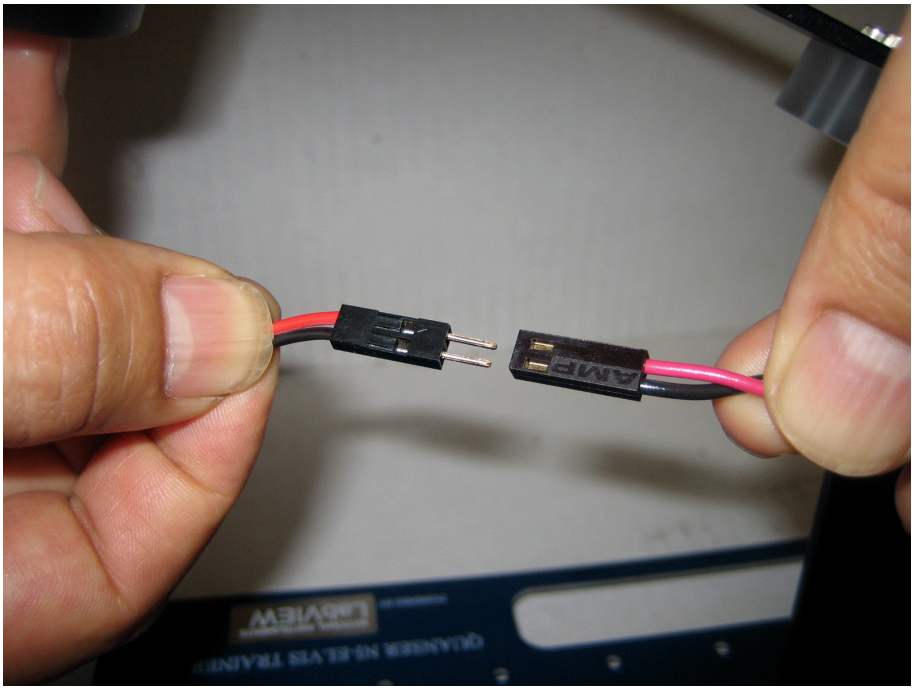


Figure 6.9: Connect motor cable

■ **Caution:** Ensure the red and black wires are connected to each other.

6. Connect the encoder cable from the QNET PWM/Encoder board to the encoder connector on the VTOL, as shown in Figure 6.10.

Figure 6.10: Connect encoder cable

■ **Caution:** Make sure the signals of the cable and encoder match, e.g. Ch. B on connector is connected to Ch. B on encoder.

Figure 6.11: Position counter-weight

7. The final assembly of the QNET-VTOL is shown in Figure 6.11. You can vary the position of the counter-weight at the end of the VTOL body. It is recommended to move the mass as far away from the propeller without actually lifting the propeller itself, i.e. it should still be resting on the QNET module.

7 SETUP GUIDE

As illustrated in Figure 7.12, the QNET boards can easily be connected to an NI ELVIS system. The instructions in Section 7.1 detail the setup procedure for using a QNET with an NI ELVIS II.

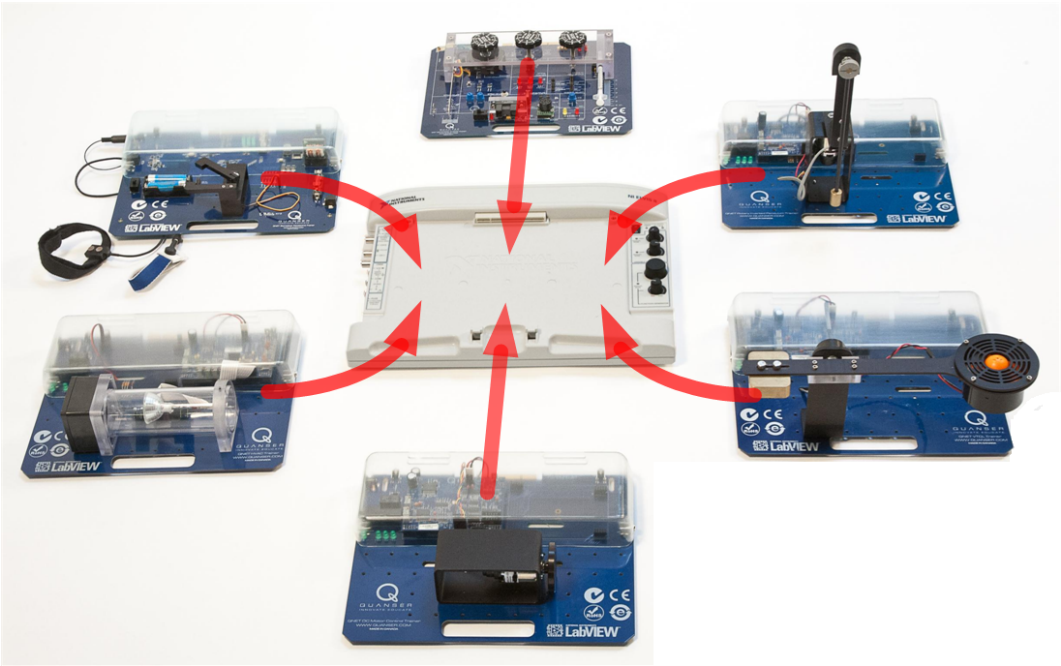


Figure 7.12: Connecting a QNET Trainer

■ **Caution: Do not position the ELVIS II so that it is difficult to disconnect the main power.**

■ **Caution: If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.**

7.1 QNET AND NI ELVIS II SETUP

The procedure to install a Quanser Engineering Trainer (QNET) module on the NI ELVIS II is detailed in this section. The NI ELVIS II components used in the installation procedure are located and marked by an ID number in Figure 7.13, and described in Table 6.

7.1.1 ELVIS II Components

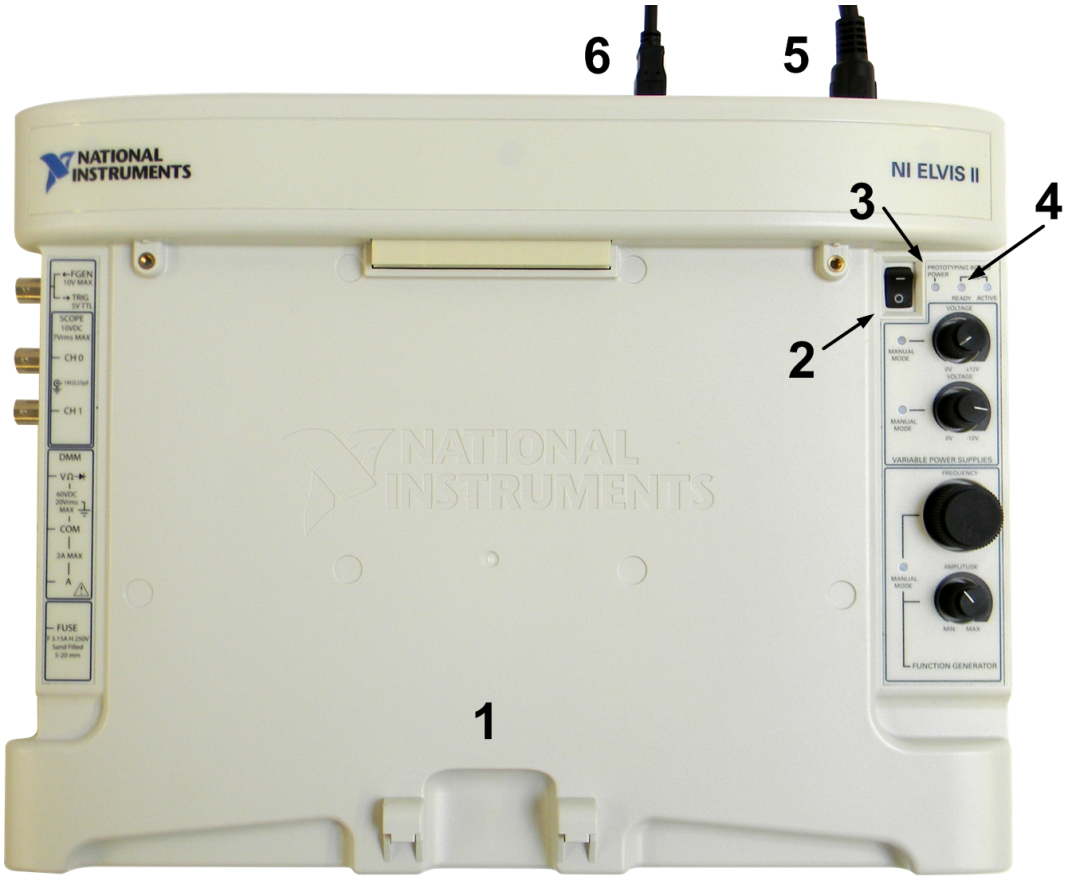


Figure 7.13: Components on ELVIS II

ID#	Description
1	NI ELVIS II
2	Prototyping board power switch
3	Power LED
4	Ready LED
5	Power Cable for ELVIS II
6	USB Connection between PC and ELVIS II

Table 6: ELVIS II components

7.1.2 ELVIS II Setup Procedure

Follow these instructions to setup a QNET board on an ELVIS II:

■ **Caution: Do NOT make the following connections while power is supplied to the hardware!**

■ **Caution: The unit is provided with a grounded cord to be used with a properly grounded outlet only, this is a safety feature, do not disable it**

1. Place the small opening on the front of the QNET board over the mounting bracket on the NI ELVIS II.
2. Slide the PCI connector of the QNET module end into the female connector on the NI ELVIS II. Make sure it is connected properly.
3. Connect the ELVIS II power cable.
4. Connect the ELVIS II USB cable to the PC.
5. Connect the supplied QNET transformer to the QNET power jack on the QNET module.
6. Power the NI ELVIS II by turning ON the *System Power Switch* on the rear panel.
7. Turn ON the *Prototyping Board Power* switch, ID #2 shown in Figure 7.13.
   - ■ **Caution: Turn OFF the *Prototyping Board Power* switch if the DC motor begins to turn!**
   - ■ **Caution: Take extra care when powering the QNET module to avoid causing any damage!**
8. The *Power* and *Ready* LEDs of the NI ELVIS II unit should be lit as shown in Figure 7.14.

Figure 7.14: Ready and Power LEDs on NI ELVIS II

9. As pictured in Figure 7.15, verify that the *+15V*, *-15V*, *+5V*, and *+B* LEDs on the QNET module are lit. They indicate that the board has been properly connected to the ELVIS unit.

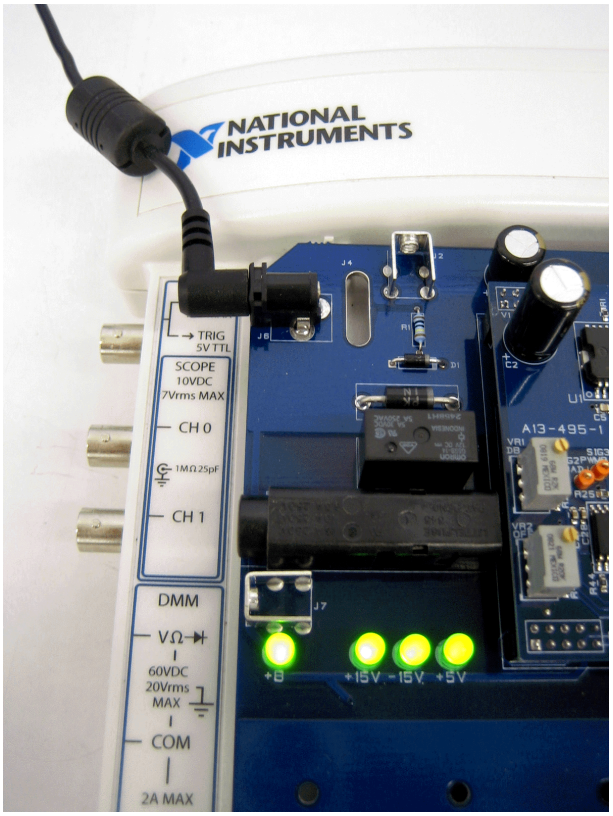


Figure 7.15: QNET LEDs should all be ON

8 QNET LABVIEW HINTS

8.1 SCALING SCOPES

This section describes a handy method of changing the x or y axis in a LabVIEW scope using *QNET_DCMCT_Swing_Up_Control* VI as an example. Read the steps below to reduce the y-axis range of the Angle (deg) scope shown in Figure 8.16 in order to see the blue trace more up close.

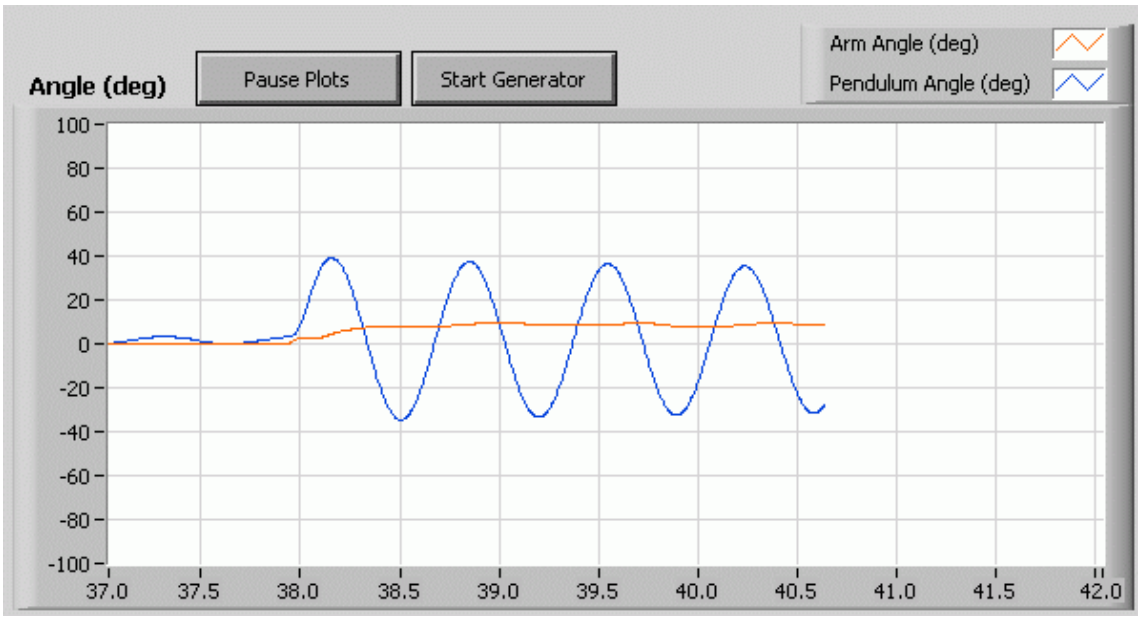


Figure 8.16: Scope needs to be scaled

1. As illustrated in Figure 8.17, to decrease the positive range of the scope down to 40, double-click on '100' in the y-axis, type in '40', and press ENTER.

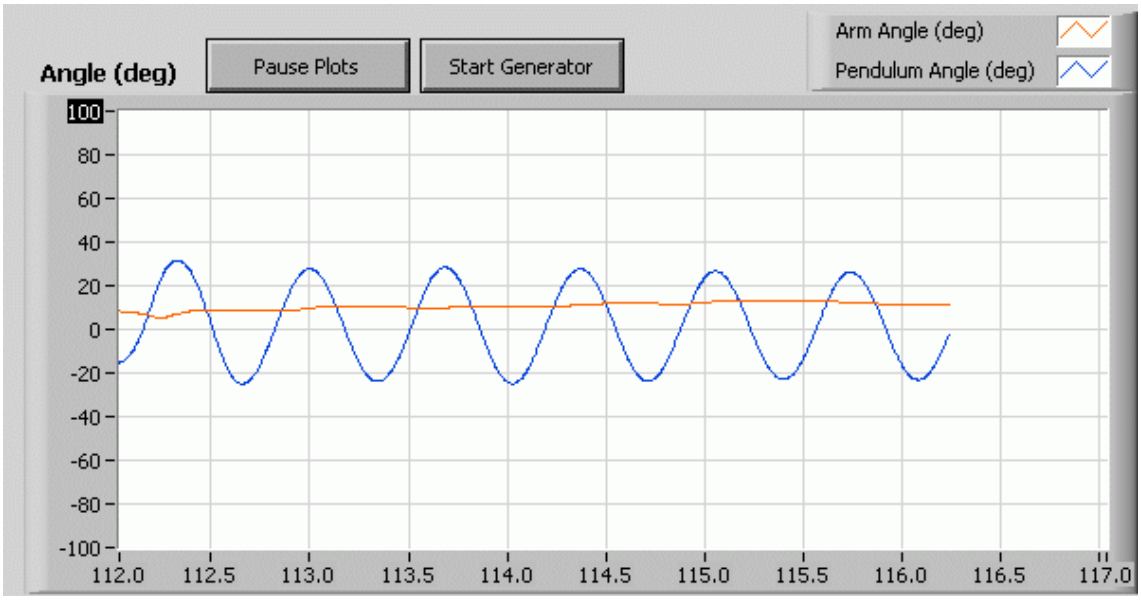


Figure 8.17: Scope needs to be scaled

2. The resulting scope is depicted in Figure 8.18. The blue trace is now more visible.

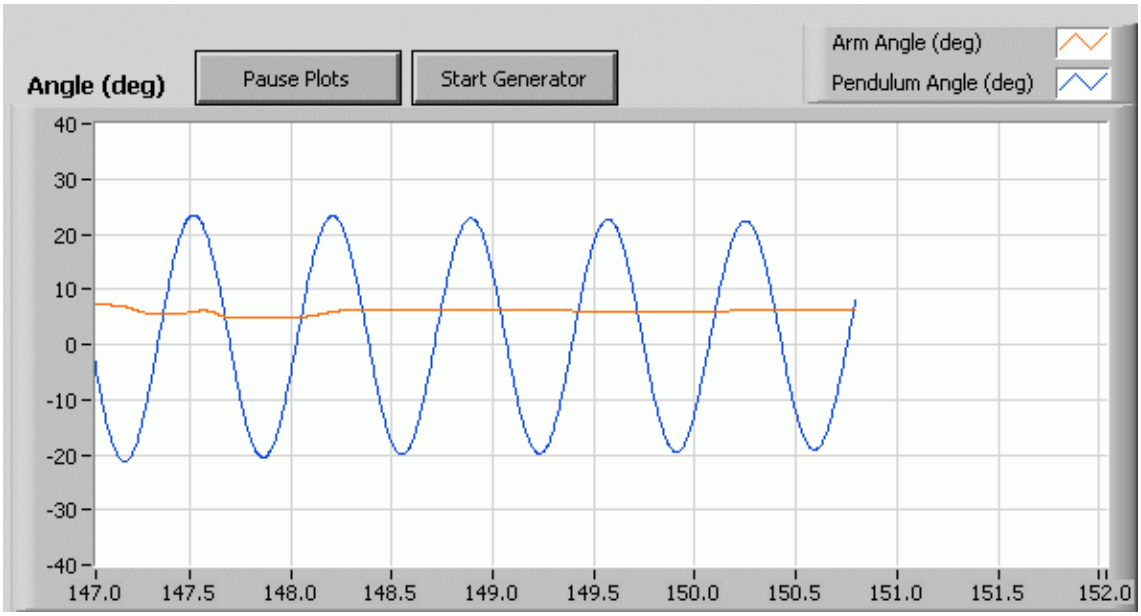


Figure 8.18: Y-axis of scope has been adjusted

Similarly, the minimum range of the y-axis can be changed as well as the range of the x-axis. For example, to see a time range of 10 seconds instead of 5 seconds the x-axis range can be changed from [0.0, 5.0] to [0.0, 10.0]. However, when changing the x -axis, i.e. the time-scale, it is recommended to do the following:

1. Pause the scopes or stop the VI and clear the chart (right-click on scope, select Data Operation || Clear Chart).
2. Apply the same scale change to both the output and input scopes. Otherwise, the data plotted in each scope will not be synchronized with each other.

8.2 SAVING RESPONSE

Read the following to save a scope response:

1. Right-click on the scope and select Export Simplified Image, as shown in Figure 8.19

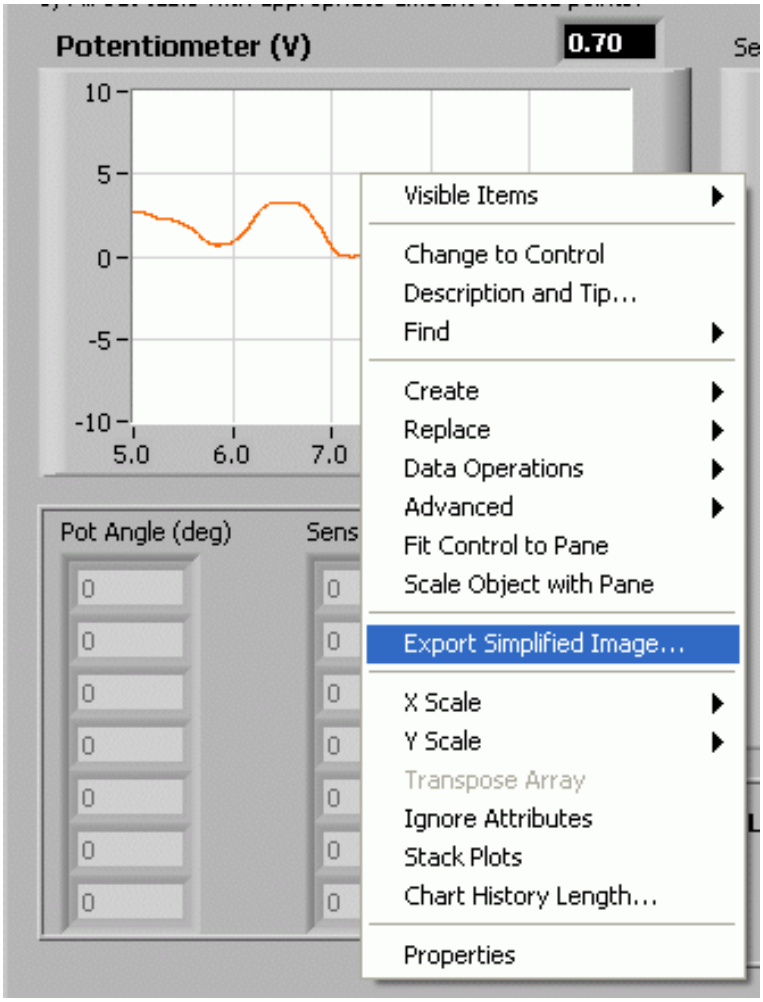


Figure 8.19: Right-click on scope and select Export Simplified Image

2. The dialog box shown in Figure 8.20 opens and gives various image export options. One way is to export the image to the clipboard as a bitmap. This can then be pasted in a graphical software (e.g MS Paint, Irfanview) and saved to a desired format (e.g. gif).

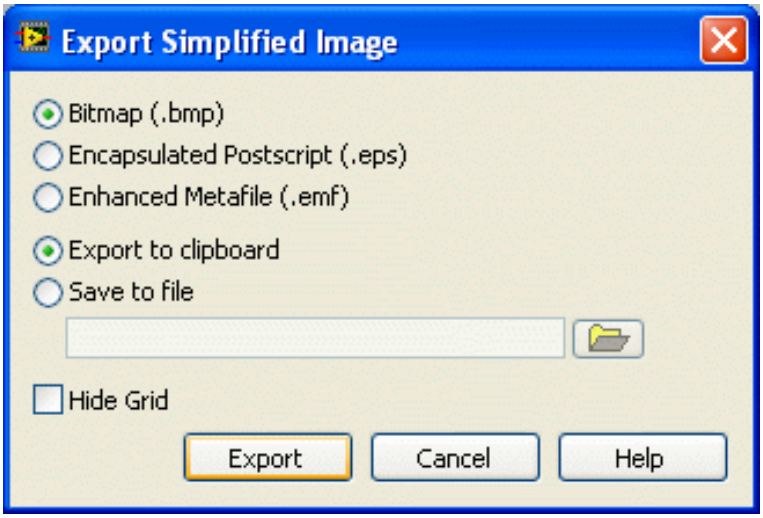


Figure 8.20: Export Simplified Image dialog box

3. The resulting image that is saved is shown in Figure 8.21.

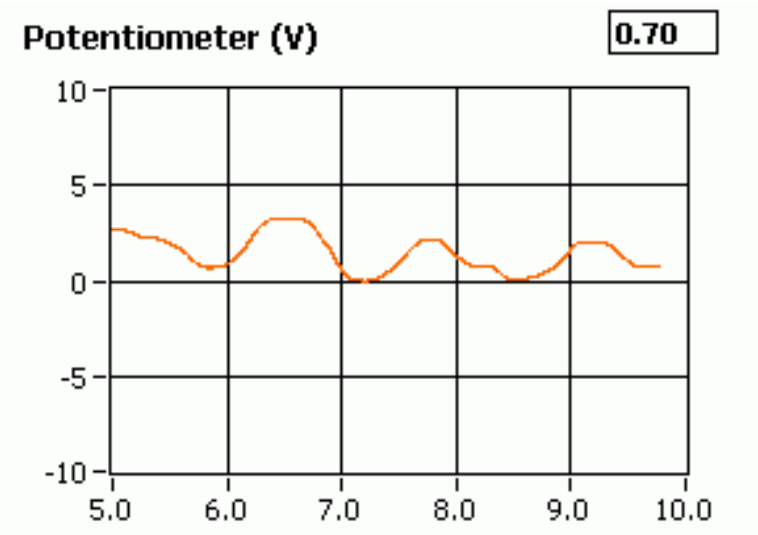


Figure 8.21: Sample saved response

The scope can be saved whether or not the VI is running. However, typically it is easier to stop the VI when the desired response is collected and then export the image as instructed above.

9 TROUBLESHOOTING

9.1 GENERAL SOFTWARE ISSUES

Q1 When I try to open a QNET VI, it says there are some missing VIs and they have a "CD" or "Sim" in the name?

The *LabVIEW Control Design and Simulation Toolkit* is not installed.

□□□

Q2 When I open a QNET VI a message prompts that a VI with "ELVIS" in the name cannot be found?

- ELVIS I: The QNET VIs use drivers that are installed from the ELVIS 3.0 or later CD. Make sure it is installed. If the folder "\National Instruments\NI ELVIS 3.0" does not exist then it is not installed (available for download at www.ni.com as well).
- ELVIS II: The QNET VIs use the ELVISmx drivers. Make sure you install the contents of the ELVIS II CD before attempting to open any of the QNET VIs (available for download at www.ni.com as well).

□□□

9.2 GENERAL HARDWARE ISSUES

Q1 None of the LEDs on the QNET board are lit?

Make sure both the *System Power* switch, which is located on the back of the ELVIS I and II units, and the *Prototyping Board Power* switch, which is situated on the front panel of the ELVIS I and on the top-right corner of the ELVIS II, are ON. See the QNET Setup Guide for more information.

□□□

Q2 On the QNET board, the +15V, -15V, and +5V LEDs are bright green but the +B LED is not lit?

Ensure the QNET power connector on the QNET board is connected with the supplied QNET power cable. See the QNET Setup Guide for more information.

□□□

Q3 At least one of the +B, +15V, -15V, and +5V LEDs on the QNET board is not lit?

- See Q2 if only the +B is not lit.
- If one or more of the +15V, -15V, and +5V LEDs is not lit then a +/-15V or +5V fuse(s) on the *Protection Board* of the NI-ELVIS I is burnt. Similarly, if the +B LED is still not lit after connecting the QNET power then the *Variable Power Supplies Fuses* on the ELVIS *Protection Board* are burnt. See the *Protection Board Fuses* in the NI ELVIS User Manual and replace the fuses as directed.

□□□

Q4 The *Ready LED* on the ELVIS II does not go on?

1. Go through the ELVIS II setup procedure outlined in the QNET Setup Guide
2. Once completed, launch the *Measurement & Automation Explorer* software.
3. As illustrated in Figure 9.22, expand the *Devices and Interfaces* and *NI-DAQmx Devices* items and select the NI ELVIS II device.
4. As shown in Figure 9.22, click on the *Reset Device* button.
5. Once successfully reset, click on the *Self-Test* button.
6. If the test passed, reset the ELVIS II (i.e. shut off the *Prototyping Board* switch and *System Power* switch and turn them back on again). The *Ready LED* on the ELVIS II should now be lit.

□□□

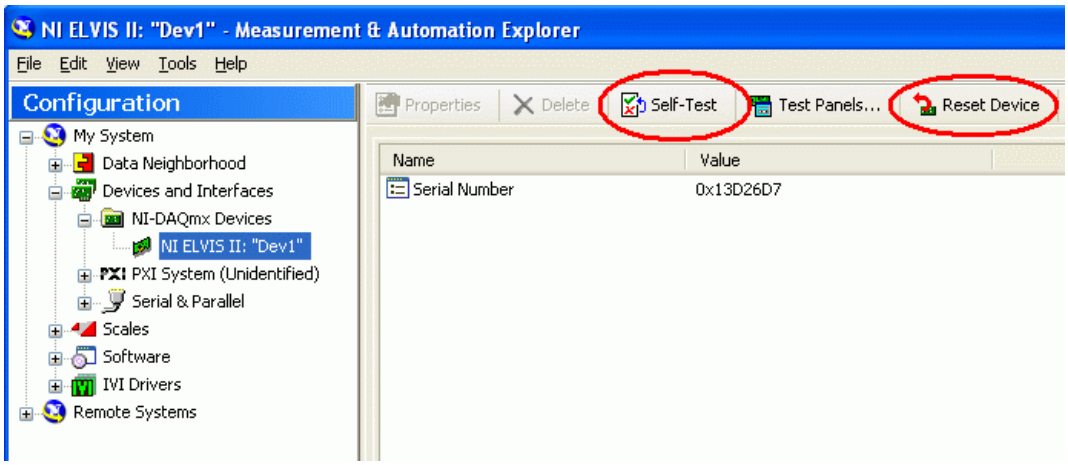


Figure 9.22: Reseting and performing the self-test on the ELVIS II

10 TECHNICAL SUPPORT

To obtain support from Quanser, go to http://www.quanser.com/ and click on the Tech Support link. Fill in the form with all the requested software and hardware information as well as a description of the problem encountered. Also, make sure your e-mail address and telephone number are included. Submit the form and a technical support person will contact you.

Six QNET Trainers to teach introductory controls using NI ELVIS

QNET DC Motor Control Trainer
teaches fundamentals of DC motor control

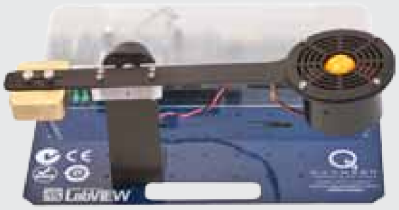
QNET HVAC Trainer
teaches temperature (process) control

QNET Mechatronic Sensors Trainer
teaches functions of 10 different sensors

QNET Rotary Inverted Pendulum Trainer
teaches classic pendulum control experiment

QNET Myoelectric Trainer
teaches control using principles of electromyography (EMG)

QNET VTOL Trainer
teaches basic flight dynamics and control



NI ELVIS I

NI ELVIS II

Quanser QNET Trainers are plug-in boards for NI ELVIS to teach introductory controls in undergraduate labs. Together they deliver added choice and cost-effective teaching solutions to engineering educators. All six QNET Trainers are offered with comprehensive, ABET*-aligned course materials that have been developed to enhance the student learning experience.

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